DOCUMENT RESUME

ED 235 046 SE 043 339

AUTHOR	Jones, Natalie; Hughes, Wyn
TITLE	Soap. Third World Science.
INSTITUTION	University Coll. of North Wales, Bangor (United Kingdom). School of Educaton.
SPONS AGENCY	Training Services Agency, London (England).
PUB DATE	82
NOTE	34p.
AVAILABLE FROM	The Centre for World Development Education, 128 Buckingham Palace Road, London SW1W 9SH.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Botany; *Chemistry; Cultural Activities; *Developing Nations; Elementary School Science; Foreign Countries; Intermediate Grades; Laboratory Procedures; *Manufacturing; Science Education; *Science Experiments; Secondary Education; *Secondary School Science; Technology
IDENTIFIERS	*Soaps; *Third World Science Project; United Kingdom

ABSTRACT

This unit, developed by the Third World Science Project, is designed to add a multicultural element to existing science syllabi (for students aged 11-16) in the United Kingdom. The project seeks to develop an appreciation of the: boundless fascination of the natural world; knowledge, skills, and expertise possessed by men/women everywhere; application of knowledge and skills to solve the practical problems of everyday life; impact of modern technology in the world; and the influence of the cultural background on the perception of knowledge, problems, and solutions. The unit begins with a brief history of soap-making in Britain and the small-scale preparation of soap in Third World countries using local knowledge, skills, and materials. This is followed by: (1) experiments related to soap-making practices by Ghanian villagers and the chemistry of banana ashes; (2) discussions of applying science to industry in Ghana soap-making (considering acids/bases/salts, sodium/potassium soaps, caustic soda manufacturing, and electrolysis of brine) and the general theory of soap-making (focusing on raw materials, equipment, soap manufacturing processes, and packaging); and (3) a brief description of how palm-oil can be obtained from the pericarp of the oil-palm fruit and its use in village soap industry. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED235046

third world science

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

SOAP

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Lois Wyn Williams
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE043339

THIRD WORLD SCIENCE

Third World Science seeks to develop an appreciation of:

1 The boundless fascination of the natural world

2 The knowledge, skills and expertise possessed by men and women everywhere

3 The application of knowledge, skills and expertise to solve the practical problems of everyday life

4 The impact of modern technology in the third world

5 The influence of the cultural background on the perception of knowledge, problems and solutions

The following Units have been designed to fit into existing science syllabuses in the United Kingdom:

CARRYING LOADS ON HEADS: CHARCOAL: CLAY POTS:
DENTAL CARE: DISTILLATION: ENERGY CONVERTORS:
FERMENTATION: HOUSING: IRON SMELTING: METHANE DIGESTORS:
NATURAL DYES: PLANTS AND MEDICINES: SALT: SOAP.

The method of use is not closely prescribed. As resources teachers may use them in different ways though suggestions are offered. Feedback is invited from teachers concerning (a) the use made of the material (b) pupils reactions, if possible in their own words, and (c) suggestions for improvements, additions etc.

Please send feedback, ideas and requests to:

Professor Iolo Wyn Williams
Third World Science Project
School of Education
University College of North Wales
BANGOR
Gwynedd, U.K.
Tel: 0248-51151

Copyright: Third World Science Project 1982

SOAP

Teacher's Notes

Soap has been made for many centuries in different parts of the world. Today soap in industrialised countries is produced by many complex processes but in certain under-developed countries soap is manufactured in rural areas by employing the basic scientific principles of soap making on a small industrial scale.

The unit begins with a brief history of soap making in Britain, the Third World and also the origin of giant chemical industries such as Unilever and I.C.I., and their involvement in the Third World, but due to economic conditions many people cannot obtain or afford this luxury soap, so they manufacture their own soap on a small scale using local knowledge, skill and materials.

This is followed by some suggestions on possible project work with references and sources for material.

A laboratory preparation of soap making similar to the method practised by Ghanaian villagers is detailed step by step followed with some suggestions on possible experiments using the soap produced.

The section on the chemistry of banana ashes outlines that soap can be produced from plants, and suggested work on the anylsis of banana ash solution, suitable for fifth or sixth forms. The titration experiment was conducted by Trevor Roach, who was engaged as a research assistant on this project from September 1979 to January 1980 at the University College of Swansea after a period as a volunteer teacher in Ghana.

An extract from a report by the Technology Consulting Centre at the University of Science and Technology, Kumasi, Ghana on the small scale industry of Ghana explains the chemistry of soap making and how they went about producing their own soap from local materials.

The unit concludes with a brief description on how palm-oil can be obtained from the pericarp of the fruit of the oil-palm and its use in village soap industry.

SOAP

Contents

		Page
1.	A Brief Study of the History of soap making in Britain	1
2.	Soap in the Third World	2
3.	Suggestions on possible project units	5
4.	Soap Making - As Practised by Ghanaian Villagers i) Laboratory preparation ii) Additional Experiments	7
5.	The Chemisty of Banana Ashes i) Suggested Experiments ii) Determination of the Ratio of Carbonate and Hydroxide Ions in Banana Ash Solutions	10
6.	Brief History of the Technology Consulting Centre at University of Science and Technology, Kumasi, Ghana Applying Science to Industry in Ghana Soap Making	12
7.	Sodium Soap and Potassium Soaps	15
8.	Manufacture of Caustic Soda	15
9.	The Electrolysis of Brine	16
10.	Extract from the T.C.C. Report on the Small Scale Industry of Ghana General Theory of Soap Making i) Raw materials ii) Equipment iii) Process of Soap Manufacture iv) Packaging	17
11.	The Oil-Palm	22
12.	References	26

SOAP

Soap is something we all take for granted, it is so common that washing our hands with it is almost an unconscious effort. Yet the bar of soap contains an interesting chemistry and an interesting history. A study project on the history of soap production has the potential to involve a number of disciplines, namely history, chemistry and geography.

A Brief Study of the History of Soap Making in Britain

It is difficult to say where and when soap was first made. It is unlikely that the Romans used soap before the Christian Era, although they did use a mixture of oils and ashes to wash with, but this was not saponified (made into soap). However, in 385 A.D. soaps were preferred by the Romans, people still have this preference today. These hard soaps were produced from sodium carbonates (soda-ash) mainly, although this was a slow process. The soda-ash was produced from the ashes of a plant called 'barilla' (salsola soda) or from a substance called 'natron' which was the name given to salt deposits in lakes found in Egypt. The abundance of soda in the Far East led to the Arabs becoming expert soap producers; in medieval times, they used to export scented soap from Damascus as a luxury product.

Soaps are basically potassium or sodium salts of long chain fatty acids - such as stearic acid. These acids are obtained from oils and fats, where they are combined with hydroxy compounds such as glycerol in the form of esters. On reaction with potassium or sodium hydroxide the soap is separated from the glycerol.*

In Britain not much mention is made of soap until the 9th Century. The Saxons used to make soap from wood ashes and animal tallows or fish oils. The soap would have been soft and smelly and would probably have been used for washing textiles only. Before the late 18th Century, barilla was imported to enable hard soap to be made, the ashes from a certain seaweed called kelp was also used. Provision of these two materials led to most of the soap making factories being situated in coastal towns such as Bristol. In 1790 the Frenchman Nichol Leblanc discovered how to produce soda from common salt; this discovery paved the way for large scale production of synthetic sodium hydroxide and in turn for large scale soap production.

* *Soda or Soda-ash* = Na_2CO_3 *Potash* = K_2CO_3

Caustic Soda = $NaOH$ *Caustic Potash* = KOH

Sodium hydroxide is much better for soap making than sodium carbonate as it produces a much 'sharper lye' (a more alkaline solution) which speeds up the process. Thus it was during the Industrial Revolution that the alkali became more readily available for soap production and this corresponded with an increased demand for soap. This boom in soap production exceeded the supply of fats and tallows in Britain and so they were imported chiefly from Russia. However, the Crimean War cut off this supply and alternatives had to be found. Mutton Tallow was imported from Australia but increasingly more and more vegetable oils were imported from other parts of the Empire: palm oil kernel from West Africa, coconut oil from the South Sea Islands, Ceylon and the East Indies.

It is during the early 19th Century that the giant chemical companies of today have their origins, companies such as Unilever and I.C.I. They owe their growth to the development of chemical science and the industrialisation of processes such as soap making during the 19th Century. It is interesting to note that the work on soapless detergents developed most rapidly during the Second World War when, as with the Crimean War, the supply of oils and fats was again endangered. A study into the rise of the multinational chemical companies and the history of the industrial processes provides a fascinating insight into the ingenuity of the people of that time. Some relevant references are given at the end of this article.

Soap in the Third World

In West Africa today soap is produced industrially by multinational companies such as Unilever, however their soap is often in short supply due to the poor economic conditions of developing countries. Imports of materials for soap making may be erratic and machinery often breaks down due to the lack of spare parts. Quite often people cannot afford to buy soap, especially the poor farmers in rural areas and these people rely on the cottage craft industry of soap making similar to the method which was common in Britain before the Industrial Revolution. Soap making as a village industry was in existence many centuries before the big factories established themsleves.

It is not certain how the skill of soap making came to West Africa. One possibility is that the skill spread across the trans-Saharan trading routes from Arabia during the time of the Ghana Empire which flourished from about 800-1050 B.C. The Ghana Empire was south of the Sahara Desert in the region known today as the Sahel; it was rich and powerful and traded with North Africa with gold and ivory in return for salt. The power and wealth of the Ghana

Empire became legendary: writing in the 12th Century at the court of the Norman King Roger II of Sicily, the traveller Al-Idrisi described how the Lords of Ghana would often feed thousands at a time, spreading banquets more lavish than any man has ever seen before. An Empire as rich as Ghana would probably have imported the scented soap made in Damascus and sooner or later the skill itself would have been imported.

The old Ghana Empire lay well to the north of the present day State of Ghana, but it was from this southern region that the Empire collected its gold for trading. This is why modern Ghana has adopted the name. The study of soap making in modern Ghana serves as a useful illustration of the development problems facing Third World Countries today. Soap making in the Ghanaian village can be compared with the soap making processes in Britain before the start of the 19th Century and thus the question can be asked - if Britain was able to increase its production of soap by the use of industrial processes why can't Ghana? An advanced technology already exists in the Western World and can be imported into Ghana to produce soap on a massive scale. Unilever is in Ghana today producing Lux soap, however, the performance of large factories is very dependent upon the economic well-being of the country. If imports of raw materials (mainly sodium hydroxide) are costly and infrequent, production falls, prices increase and profits diminish. Under these conditions there is little incentive for Unilever to expand its operations to provide soap which is cheap enough and abundant enough for all Ghanaians. If the people in the villages are already making soap which is within their financial means to produce, perhaps it would be better to start with this process and use a scientific approach to improve the quality of the soap and increase the production levels so that the needs of the community are met, at the same time insuring that the technology does not involve the use of complex machinery which needs expert attention and imported parts, but uses local skills, local materials and local manpower. Such a solution is an example of appropriate technology.

To understand the process of soap making in the village, soap can actually be made in the school laboratory from the ash of banana skins and vegetable oils, preferably palm oil or coconut oil (see experiment sheet for details). From analysing the type of soap produced, pupils can assess for themsleves the possibilities for improving the process.

The Technology Consultancy Centre of the University of Science and Technology in Ghana has designed a tank which can be constructed locally from readily available materials and is capable of producing half a ton of soap per day. The method of soap production is similar to the local method and involves

no extra skills, the only difference is that caustic soda is used in preference to pot ash because a hard soap is preferred by the villagers. The supply of caustic soda can be a problem because to import it for small production can be very expensive so methods have to be found of overcoming this problem. At present calcium carbide has to be imported for the production of acetylene for use in construction and engineering, slaked lime is produced as a by-product of the process.

$$\underset{\text{calcium carbide}}{CaC_2} + \underset{\text{water}}{2H_2O} = \underset{\text{acetylene}}{C_2H_2} + \underset{\text{slaked lime}}{Ca(OH)_2}$$

Hitherto, this slaked lime was a waste product and not put to any good use, but now the Technology Consultancy Centre has designed a process which uses the slaked lime to produce caustic soda. Again the construction of the processor requires the use of locally available material and local skills. The finished plant is inexpensive and can be bought by the soap makers and operated by them providing an on-site supply of caustic soda. The process involves reacting slaked lime with soda ash (sodium carbonate) and caustic soda is produced according to the equation.

$$\underset{\text{slaked lime}}{Ca(OH)_2} + \underset{\text{soda ash}}{Na_2CO_3} = \underset{\text{caustic soda}}{2NaOH} + \underset{\text{calcium carbonate}}{CaCO_3}$$

Although the soda ash has to be imported it is much cheaper than caustic soda because it has to be imported in large quantities for water treatment, glass making and other industries. In 1978 it was costing a soap maker* 1 cedi to produce 1 kilo of caustic soda from slaked lime, whilst the imported caustic soda cost 40 cedis a kilo - a big saving. The existence of some soda ash in the final soda solution is acceptable because sodium carbonate is often added to soap as a filler.

When all the slaked lime from the acetylene is being utilised it is estimated that the amount of soap which can be produced will cover about 5% of Ghana's soap requirements, other sources of cheap caustic soda are obviously required. One possible solution is the production of caustic soda from the electrolysis of brine. For this process electricity and sea water are needed, Ghana can provide both in abundance, the Akosombo Dam produces a large amount of electricity from its hydro-electric station. However, the electrodes are expensive and at the moment there is no big demand for the other product of the

* £1 = ¢5.6 in July 1979.

process which is chlorine. The time is fast approaching when small scale electrolysis plants can be produced, cheaper longer lasting electrodes are being developed and use for the chlorine can be found in water treatment and in the production of bleaches and detergents.

The point to emphasise with this development is that the labour and the ingenuity of the Ghanaian is being utilised with a moderate financial return for his effort and a minimum requirement upon imported goods. This form of appropriate technology meets the needs of the majority of people more adequately than the advanced technology of Unilever operating a factory which employs relatively few people because of its automation, imports a large quantity of material and produces a soap which can only be purchased by the more wealthy Ghanaians.

Project Work

On this topic of soap the possibility exists for the Chemistry, History and Geography departments to work together to produce an interesting project. Alternatively there is enough science content in this topic for it to remain within the scope of the science lesson alone.

Possible Project Units	Some References and Sources of Material
a) Soap manufacture and use before the Industrial Revolution see Addendum p 6a 'Burning Bracken'	1. Enterprise in Soap and Chemicals A.E. Musson, Manchester University Press, 1965 2. 'Detergents' - Unilever Educational Booklet, Revised Ordinary Series No. 1 3. Glamorgan County Historian Vol. iv, 1974 pp 346,7,8. (Archives from other countries would also probably provided information on trade in ashes, barilla, kelp, soap, oils or tallow) 4. A History of Industrial Chemistry, F.Sherwood Taylor, Heinmann 1957 Ch. 10
b) The Growth and Technical Development of soap production during the Industrial Revolution.	1. Education in chemistry March 1977, 'William Gossage 1799-1877' byDr. D.J. Adam. 2. The History of Unilever Vol. 1 C.W. Wilson, Cassell, 1954

		3. Imperial Chemical Industries W.J. Reader, A History Vol. 1 OUP, 1970
c)	World Trade in oils and fats for the detergent and margarine industries	1. Vegetable Oils and Fats, Unilever Education Booklet, Revised Ordinary Series No. 2.
d)	The Chemistry of soap making	1. Preparation of Soap, Unilever Laboratory experiment No. 1 2. Detergents, Unilever Educational Booklet, Revised Ordinary Series No.1 3. The Chemistry and Manufacture of Soaps and Soapless Detergents (booklet) Procter and Gamble Education Service 4. Soaps and Soapless Detergents (pamphlet) Procter and Gamble Education Service
e)	Soap making from banana skins in the laboratory	See Information Sheet
f)	Soap making in Ghana and the problems of development	Technology Consultancy Centre of the University of Science and Technology, Kumasi, Ghana. Report on the Development and Transfer of an Intermediate Technology for the Small Scale Soap Industry of Ghana.

BURNING BRACKEN

Some 200 years ago it was a common practice to burn bracken to produce ash for making potash for soap making. It is known that this practice was carried out in areas of North Wales, states Ifor Davies a 99 year old historian and researcher from Conway. (Interviewed by B.B.C. Radio Cymru)

To produce a small amount of ash involved a lot of hard work, as the ash was so light and fine in texture. The bracken grew in abundance on the hillsides and in the valleys of Wales.

Ifor Davies recalls an interesting account concerning a Nanws ach Roberts of Dolwyddelan in the Lledr valley. During the first half of the 18th century at the time of the religious revival, in an effort to raise money towards building a chapel, she decided to burn bracken to sell the ash - the chapel was completed in 1783 and named Capel yr Ynys.

The procedure was to cut down the bracken when fully grown, left to dry, burn and collect the ash into sacks, which had to be tighly secured because the ash was so fine. The sacks containing the ash were then transported to Trefriw.

Having worked diligently, the result of her labour was 30 pecks of ash for which she had to burn a vast amount of bracken, 1 peck being equal to 2 gallons, her total amount being 60 gallons for which she was paid 6/= (30p) per peck - total amount received £9.

Mr. Roberts goes onto recall an interesting chat between Nanws ach Roberts and Sion Buarth Tangwys, a representative for a merchant named Mr. Boon.

"How much ash do you have this year?" asked Sion, "and how much are you asking for it?" Nanws answered "The ash hasn't been weighed, so therefore I can't quote you a fair asking price. While dealing with me, treat me as you would expect to be treated yourself by others. Remember that the Lord sees and knows all, and every act will be brought to judgement".

It was customary to burn bracken in the Beddgerlert area. In the book published in 1899 'Beddgelert, its Facts and Folklore' by D. Jenkins, it states that the buildings alongside the banks of the river Glaslyn were used as warehouses for storing the bracken ash.

The process of bracken burning was also carried out in parts of England, including Westmoreland and Lancashire. At Cartmel-in-Furnness during the 17th century 'Bracken Day' was held yearly, and at Wallman Crag traces have been found of bracken burning ovens which consisted of low circular stone walls.

SOAP MAKING - AS PRACTISED BY GHANAIAN VILLAGERS

Materials (For Laboratory Preparation)

8 banana skins
Palm oil or coconut oil (this can be purchased from some Asian Stores)
pH papers (pH range 7-14)
Crucible
200ml beaker
200ml conical flask
Tripod and gauze
2 bunsen burners
Glass rod
Thermometer
1 old 16 oz tin

NB. The pH papers and thermometer have to be used by the pupils in place of the village producers own judgement, which is acquired by experience.

Procedure

1) Dry the banana skins in the sun (or over a radiator). When they are bone dry, burn them to a black ash in an old tin using a bunsen flame.

2) Crush the black ash into a powder and place it in a crucible. Heat the crucible as strongly as possible so that the ash begins to glow - an extra bunsen flame may have to be directed onto the top of the ash to achieve this. Continue heating and turning the ash until it is white.

3) Weigh out approximately 4 grams of the white ash and mix this into 150mls of water. The pH could be checked with litmus paper. (About 9)

4) This mixture is heated to $60^{o}C$ for 5 minutes and allowed to cool.

5) When cool enough, filter the mixture through a filter paper and funnel into a 200ml conical flask. Re-check the pH. (The pH should have risen from about pH 9 to pH 12).

6) Place $25cm^3$ of palm oil into a $200cm^3$ beaker and slowly heat it under a bunsen until it reaches a temperature of $50^{o}C$. When the temperature of the oil is at $50^{o}C$, stop further heating and add $75cm^3$ of the filtered banana ash solution. This $75cm^3$ of solution should be added in small portions and with vigorous mixing. If this is done properly a homogeneous emulsion is produced. If the banana ash solution is not added in portions and mixed in thoroughly the oil will separate out when the mixture is boiled.

7) Once the oil and banana ash solution have been thoroughly mixed into an homogeneous state, bubbling stones are added and the mixture is slowly brought to the boil. Great care should be taken at this stage, as violent frothing will occur.

8) Once the mixture has reached boiling point, it should be boiled as vigorously as possible. The volume of the mixture should never be allowed to fall below $50cm^3$. To avoid this, keep topping the mixture up with the extra banana ash solution.

9) After 1-2 hours of boiling, the frothing will diminish and the mixture will appear to be translucent and treacle-like in consistency. Saponification is now complete.

10) At this stage boiling can be continued to reduce the volume of water and the soap is then poured into moulds to harden. Such a soap will be mixed with the glycerine and be very soft. A more popular procedure takes advantage of the fact that soap is insoluble in a saturated salt solution. If $50cm^3$ of saturated sodium chloride solution is added to the hot soap mixture and mixed well, the soap will be deposited as an insoluble layer on the surface. This procedure is known as 'salting out'. In the laboratory this layer can be sucked up by a syringe and pumped into moulds, or the beaker can be left overnight to cool and the soap will form a harder layer which can be scooped off.

The black ash from the first burning is used by Ghanaian villagers for cooking. It is a mildy alkaline (contains potassium carbonate and sodium carbonate). They know that the white ash is required for soap making. We believe that calcium oxide is found in the second stage of burning (from calcium carbonate) and that this reacts with potassium and sodium carbonate to give potassium and sodium hydroxide (stage 4 of the process).

Additional Experiments

a) The palm oil is colourless and malodorous when refined, methods can be discussed on how to make it colourless and odourless before starting the soap making process. If the oil is heated to a high temperature and small charcoal blocks are added, this will take away the smell. Frying sliced onions until they are charred will have the same effect.

b) Vegetable dyes can be added at stage (9) to give the soap a pleasing colour.

c) Fragrant oils can be mixed into the soap just before it is poured into moulds. Experiments can be conducted to see which scent keeps its fragrance the longest.

d) The soap produced from banana skin ashes is said to be a 'soft' soap as the main alkali is potassium. 'Hard' soaps are produced from sodium hydroxide, however, the banana ash soap can be made 'harder' by adding a 'filler' such as sodium carbonate at the end of stage (6). This procedure is not a traditional practice in villages, adding 'filler' was introduced into industrial soap making processes during the Industrial Revolution. Many cheap catering soaps have fillers added, this makes them so hard that they last a long time. This experiment will serve to show how the traditional methods could be built upon. The soft soap produced from the banana ashes is suitable for washing clothes. It will be noted that it does not produce much of a lather, this is reflected on the fatty acids in the oil, some types of fats and oils produce soap which lathers more readily than others. Soap made with coconut oil should produce more of a lather than soap made with palm oil.

THE CHEMISTRY OF BANANA ASHES

In living plants, salts are taken up in solution through the roots. The composition of the salt solution in the plant sap will vary according to the nature of the soil, also different parts of the plant will sometimes accumulate different salt concentrations. Plants require mineral salts to maintain critical osmotic potentials within the cells. Some salts have specific functions within the plant, for instance K^+ ions are required to maintain membrane potentials. Calcium is a major component of cell walls, PO_4 is a constituent of the important nucleotide bases. Sulphate and nitrates are present as a source of nitrogen and sulphur for protein synthesis. Plants such as some halophytes are adapted to living in soils which are highly saline and will possess high concentrations of sodium chloride in their sap. When a plant is burnt, it is reasonable to assume that the soluble salts that were present in the sap will be deposited as a mixture of crystals within the ash.

The solution filtered off from the banana ashes will be mainly a mixture of sodium chloride, potassium chloride, sodium carbonate, potassium carbonate and calcium carbonate. The solution will contain a relatively high proportion of calcium salt because banana skins have a high calcium content. The skins are low in sodium content which explains why the solution produces a soft soap. The solution also contains a certain amount of hydroxide ions, these are possibly produced as a result of some calcium carbonate being converted to calcium oxide during the burning, the calcium oxide will dissolve to produce hydroxide. In a banana ash solution the main alkali is therefore caustic pot ash (KOH). The term 'pot ash' could conceivably have originated from a solution made from the ashes which remain behind in cooking pots. If seaweed or halophytic plants are burned, the predominant alkali would be caustic soda (NaOH) arising from sodium carbonate + Ca salt. The mixture of carbonates would serve as filler to harden the soap.

Experiments

1) The ash solution or its solution would serve as an interesting mixture for inorganic analysis.

2) The banana ash solution contains a mixture of carbonate and hydroxide ions. By performing a soluble titration using two indicators the ratio of carbonate to hydroxide ions can be calculated although the exact concentration cannot because of all the other ions in solution.

Determination of the Ratio of Carbonate and Hydroxide Ions in Banana Ash Solution

Titrate 20 cm^3 aliquot parts of the banana ash solution (2 gms soaked in 100 cm^3 of water) with 0.1 M hydrochloric acid using phenolphthalein as indicator. At this end point the pink solution turns colourless. At this stage all the hydroxide has been neutralised and half the carbonate $OH^- + H^+ = H_2O$, $CO_3^{2-} + H^+ = HCO_3^-$. If methyl orange is added to this colourless solution, the titration can continue with the 0.1 M hydrochloric acid until the second end point is reached i.e. when the colour of the indicator has changed from yellow to orange, now all the carbonate has reacted as well $HCO_3^- + H^+ = H_2O + CO_2$

From the titre readings obtained, it is possible to work out the ratio of the hydroxide ions to carbonate ions.

For example:-

		1st titration with Phenolphthalein	2nd titration with Methyl Orange	volume required to neutralise CO_3^{2-}	volume required to neutralise OH^-	ratio of $CO_3^{2-}:OH^-$
1.	Carbonate alone	10 cm^3	20 cm^3	20 cm^3	0 cm^3	1:0
2.	Carbonate + hydroxide 1:1	10 cm^3	15 cm^3	10 cm^3	5 cm^3	1:1
3.	Actual experimental result	17.1 cm^3	29.40 cm^3	24.6 cm^3	48 cm^3	2.6: 1

Note that the carbonate ion will require double the volume of acid to neutralise the same number of moles as the hydroxide.

Further experiments could be conducted to determine the effect of different burning methods of banana skin on the yield of OH^- ions i.e. varying the temperature and time of burning.

3) Different plant materials could be burnt under similar conditions and equal weights of ashes soaked in water to dissolve out the salts. Comparative titrations could then be made to determine if banana skin is the best material for this soap making. The plant material with the greatest calcium content may produce a solution with the greatest $OH^-:CO_3^{2-}$ ratios.

TECHNOLOGY CONSULTANCY CENTRE

University of Science
and Technology,
KUMASI,
GHANA.

REPORT

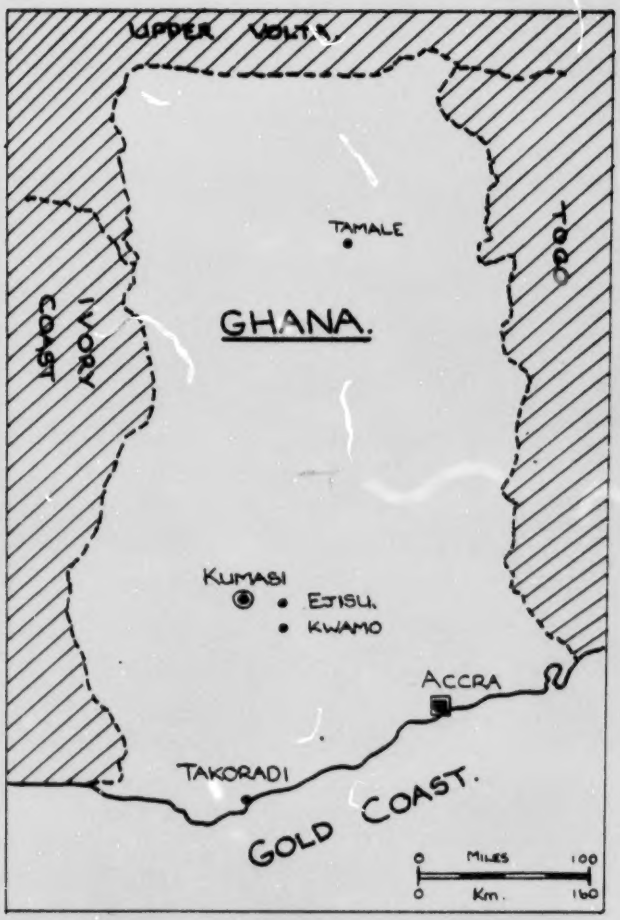
BRIEF HISTORY OF THE TECHNOLOGY CONSULTING CENTRE

Soap making at a rural level has been on a small scale, and its unscientific production techniques give way to a lot of production problems. These are normally technical in nature and give rise to poor quality soap which was soft and too caustic.

Early in 1972 the Technology Consultancy Centre was approached by numerous small scale soap makers with requests for analysis of their products and advice on the improvments of quality. It was therefore felt that help could be more effectively given if the small soap makers formed themselves into a co-operative to operate a plant under the guidance of the Centre. A soap pilot plant was designed and constructed and in September 1973, production of bar soap started on the Campus as a pilot scheme with two soap plants, each capable of producing 500 bars of the 1 kilogram bar soap a day.

The pilot plant continued to operate on the Campus until June 1975, when the project was moved to Kwamo near Ejisu, where a new soap factory has been built. (See Map)

AFRICA SHOWING POSITION OF GHANA.



T.C.C. - U.S.T. Kumasi

APPLYING SCIENCE TO INDUSTRY IN GHANA: 2

SOAP MAKING

AMONKYE SAMINA

Most of us are familiar with Amonkye soap and many of us have seen it being made. Firstly the soap maker takes plantain peels or cocoa husks which have been dried in the sun and burns them to ash. The ash is dissolved in water and the mixture is filtered to remove the insoluble material. The liquid so obtained is then boiled with a mixture of shea butter and palm kernel oil and the soap when cool is formed into the familiar hand size balls. We know the product and the process but have we thought about the scientific principles involved.

ACIDS, BASES AND SALTS

One of the first topics we study in chemistry is that of acids, bases and salts. We learnt that acid will react with a base to produce a salt and water. The oils that we use to produce soap are mixtures of fatty acids. Some of these have the following general formulae:

palmitic series	$C_nH_{2n}O_2$
oleic series	$C_nH_{2n-2}O_2$
linoleic series	$C_nH_{2n-4}O_2$

One of the commonest of these acids is called stearic acid which comes from the palmitic series and has formula $C_{18}H_{36}O_2$ (i.e. n = 18). The chemical formula is more correctly written as $C_{17}H_{35}COOH$.

When a fatty acid reacts with a potassium or sodium base if forms a salt which is a soap. The base obtained from plantain peel or cocoa pod is mostly hydroxide. The reaction between potassium hydroxide and stearic acid can be written as:

$$C_{17}H_{35}COOH + KOH = C_{17}H_{35}COOK + H_2O$$

stearic acid	+	potassium hydroxide	potassium stearate	+ water

Oils such as palm oil and shea butter actually contain a mixture of different fatty acids and so the full description of the chemical process would consist of several equations of this type.

SODIUM SOAPS AND POTASSIUM SOAPS

Everyone who has tried to use Amonkye soap knows that it is rather soft. This is a characteristic of potassium soaps. In industrialised countries, potassium soaps are used for liquid soaps and shampoos but not for bar soap or toilet soap. Potassium soaps are mild and good for the skin but they are too soft for most uses of solid soap. The great advantage to the soap maker of potassium soaps is that the base, called caustic potash, is easily obtained from local materials such as plantain and cocoa pod.

If we want to make hard soap it is necessary to replace the potassium base with a sodium base. The most common is sodium hydroxide or caustic soda. Many small soap makers make bar soap using caustic soda which they buy in the local market. However, at the present time this caustic soda is not made in Ghana. It is imported from overseas and so it tends to be scarce and expensive. Sometimes when it is not available the soap makers must stop production. Thus there is a need for a means of producing caustic soda locally in Ghana.

THE MANUFACTURE OF CAUSTIC SODA

Early in 1974, the Technology Consultancy Centre (TCC) began to produce caustic soda using the slaked lime (calcium hydroxide) waste from the L'air Liquids acetylene plant at Tema. The L'air Liquids plant uses imported calcium carbide to produce acetylene by the well known reaction with water described by the equation.

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$

When slaked lime is reacted with soda ash (sodium carbonate) caustic soda is produced according to the equation.

$$Ca(OH)_2 + Na_2CO_3 = 2NaOH + CaCO_3$$

slaked lime	soda ash	caustic soda	calcium carbonate

The reagents are not very soluble in water and so the material is agitated as a suspension in water for about 3 hours before the reaction is complete. The reaction proceeds best at a temperature of about $90^{o}C$. The calcium carbonate is precipitated as an insoluble sludge and the final solution contains about 90 per cent caustic soda and 10 per cent soda ash.

The plant produced by the TCC has a volume of about 300 gallons. It uses a 1 h.p. electric motor for stirring. One version used five 30kw electric elements and another uses a wood fire for heating. The final solution contains about 10 per cent of caustic soda by weight and can be used directly for soap making. The presence of a small amount of soda ash presents no problem as it is often added to soap as a filler and hardner.

A number of local soap makers have purchased plants from the TCC and have been making their own caustic soda for years. By making use of the waste slaked lime a significant saving of foreign exchange is effected. The soda ash must still be imported into Ghana but it is a cheaper material than caustic soda and is more abundant in the Country because it is used in water treatment, glass making and other industries. Users of this process have held the cost of their caustic soda at below ¢1.00 per kilogramme over a period during which the cost of imported caustic soda has reached ¢40.00 at times.

The TCC plant has proved to be an appropriate technology for the small-scale soap industries of Ghana. It is cheap enough for them to buy and simple enough for them to operate. However, it only enables a certain number of industries to flourish as the supply of slaked lime is limited to about 30 tons per month. If all this material was used in soap making an annual production of soap of about 3.900 tons would result. This represents about 5 per cent of the estimated national demand.

THE ELECTROLYSIS OF BRINE

A long term solution to the problem of making caustic soda in Ghana is by the electrolysis of brine. Essentially this process requires only sea water and electricity; both of which Ghana possesses in abundance. Two problems have prevented the introduction of a large scale plant. One arises from the fact that the process also produces chlorine and the demand for chlorine in Ghana does not balance the demand for caustic soda. The second problem is that the foreign exchange costs to replace the electrodes has been quite high. However, in recent years more long lasting electrode materials have been developed and there appears to be some hope of producing small scale plants which might be economically viable. The chlorine would be used for water treatment or for the production of chlorinated bleaches and disinfectants.

From Amonkye soap to the electrolysis of brine may appear to be a long road and one which is best travelled in easy stages. However the evolution of the traditional soap industry illustrates what has already been achieved by the application of science and what might be achieved in the future.

EXTRACTS FROM THE T.C.C. REPORT ON THE SMALL SCALE INDUSTRY OF GHANA.

GENERAL THEORY OF SOAP MAKING

1. RAW MATERIALS

Soap is an alkaline substance used in washing and cleaning. In chemical terms, it refers to the reduction of caustic alkalines with fatty acids which on treatment with water liberates alkali useful in cleaning garments.

The raw materials for the making of soap cover a wide range of substances which may be classified under the following headings:-

a) Fats and Oils
b) Alkalis
c) Filling Agents
d) Perfumes
e) Salt
f) Water
g) Colour or Dyes

A) Fats and Oils: Oils are divided into three classes, namely, Fixed oils, Mineral oils and Essential oils. Fixed oils form the main raw material for soap making as they decompose when strongly heated and are easily saponified by alkalis. The Centre uses palm oil - edible or sludge bought from the Takoradi State Farms. (See Map)

Fixed oils
- Animal oils and Fat
- Vegetable oils and fats
  - Oil Seeds of annual agricultural crops, e.g. ground nut
  - Oil seeds/Nuts from Perennial trees
    - Agricultural coconut, palm, rubber etc.
    - Forest and non-agric. trees; e.g. neem

Among the vegetable oils and fats, some are edible (e.g. groundnut, coconut, cotton seed, etc.) and some are non-edible (e.g. castor, physic nut, neem, etc.).

The fixed oils are further classified according to their physical properties as follows:-

i. Drying oils - e.g. linseed oil
ii. Semi-Drying oils - e.g. cotton seed oil, tobacco seed oil
iii. Non-Drying oils - e.g. coconut oil, palm oil, groundnut oil

Oils and fats under the third class are mostly employed in soap making.

B) Alkalis: Caustic soda (NaOH) and Caustic Potash (KOH) are the two alkaline materials used in the making of soap. Caustic soda produces hard soap while caustic potash produces soft soap. Both are however corrosive and hygroscopic absorbing moisture from the atmosphere.

Since it produces soap of softer consistency and more soluble in water, caustic potash is used in the manufacture of toilet soaps, shampoos etc., and is rarely used in the making of ordinary washing soaps where caustic soda is used.

C) Filling Agents: These are used to increase the bulk of the soap and to lower production cost e.g. sodium silicate, sodium carbonate, starch, china clay, Kaolin. Care should be taken for their selection and usefulness for which they are to be added. If taken too much in soap, they may deter the washing property of the soap or affect its keeping quality.

One of the most important fillers commonly used is sodium silicate, and when used in soap making in the right quantity it increases the soap hardness, smoothness, binding and transparency, and the bulk.

D) Perfume: Some oils and fats produce soap of unpleasant odour, which has to be removed by the addition of perfume. A wide range of cheap agents, natural and synthetic perfumes are normally used in soap making. The following are some few perfumes used in soap making:-

i. Lemon Grass Oil
ii. Citronella Oil
iii. Oil of Lavender
iv. Vertivert Oil
v. Geranium Oil

They are usually used as a last addition to soap.

E) Salt: Common Salt (NaCl) is required in large quantities in soap making. It is used for graining the soap out from a mixture of oils and alkalies. Soaps being insoluble in strong brine, separate out when salt is added. Usually 12% of salt by weight of oils is normally used.

F) Water: Water acts as a medium and accelerates the saponification reaction of oils and alkaline is another important raw material in the making of soap. Commercial soaps contain 28-30% of moisture.

2. EQUIPMENT

Equipment used in the manufacture of soap include the following:

a) Boiling pans - ordinary 44 gallon drums can be used as boiling pans for soap making at the rural level, but for a fairly large scale production, specially designed boiling pans can be made;

b) Caustic pan - this is used for the making of the caustic solution and must be of galvanised or enamel material;

c) Moulding boxes or frames - for holding the soap during cooling and setting - can be made of iron or wood;

d) Cutting table - required for cutting soap blocks into bars after being removed from moulding boxes/frames. (See Photograph)

e) Stamping pad - with which the manufacturers name/symbol is stamped on the soap;

f) Weighing scale - for weighing caustic soda/potash, oils, water and other raw materials, as these materials must be taken in right quantities during the soap making.

Others - Buckets for carrying water, oil or caustic solution as well as as stirring rod for stirring of the soap mixture. Rubber gloves are also recommended for caustic handling.

3. PROCESS OF SOAP MANUFACTURE

There are two processes used in the making of soap, namely, cold process and hot or boiling process.

Hot Process - Here, the right quantity of oil is put in the boiling pan and heated by firewood or coal slowly to melt the fat charge at approximately 50°C. The required concentration of caustic soda solution is then added by small quantities at a time. Each addition is allowed to react with the oil before the next is added. Any hasty addition of caustic solution may result in graining, while judicious working will keep the mass in a form of smooth homogeneous emulsion. Saponification may take about 30 minutes, after which the mass is brought to the boiling state, which must be controlled to prevent boiling over of the soap. After passing through the different stages of saponification, the mass thickens, gets more transparent and finally assumes a peculiar shiny translucent surface, free from froth - easily recognisable by

an experienced soap maker.

Completion of saponification can also be checked by unscientific method which involves taking a small sample of the soap from the boiling pan and pressing between the thumb and forefinger. Saponification is completed if the soap forms a shiny ribbon after the pressing. Placing a small quantity on the tongue also enables the free caustic in the soap to be determined. A very sharp bite on the tongue means that there is too much free caustic in the soap.

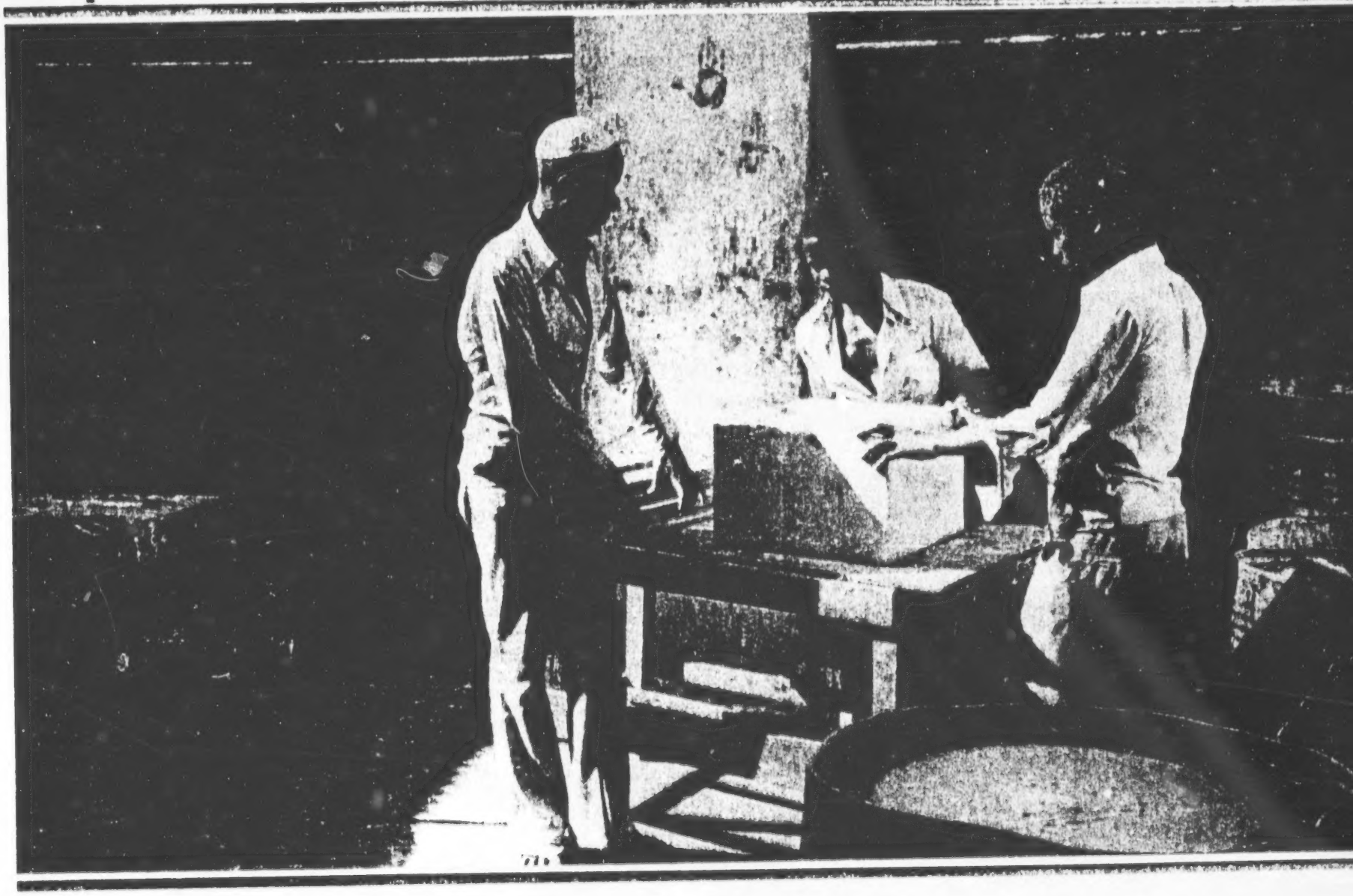
After completion of the boiling process, the fire is withdrawn and the soap allowed to cool in the boiling pan with occasional stirring. At this point colours and perfumes can be added, and the soap is poured into moulding boxes and allowed to harden for 24 or 36 hours, after which it is cut into required sizes and stamped for sale. (See Photograph)

Cold Process - A 20% caustic soda solution is made (i.e. a concentration of 0.91 kg. of caustic soda in 4.5 litres of water). The required quantity of coconut or palm kernel oil is taken. After the correct measurements of oil and caustic solution are obtained, the oil is maintained at a temperature of 39°C in the soap making plant and the caustic solution run into it bit by bit with vigorous stirring. The addition of caustic solution continues until the whole oils is saponified, when the mixture turns into hot semi-solid soap. The soap is then poured into moulding boxes and allowed to stand for about 24 hours to harden.

4. PACKAGING

Soap is normally sold in pieces instead of bars, and each bar is cut into three equal pieces weighing about 300 gms. and measuring 3.7 x 6 x 12.3 cm. Sixty pieces are then packed in a carton which is bought from the Takoradi Paper Conversion Corporation. The carton with the Centre's "Anchor" trade mark label pasted on it is then sealed and ready for the market for sale to the University staff.

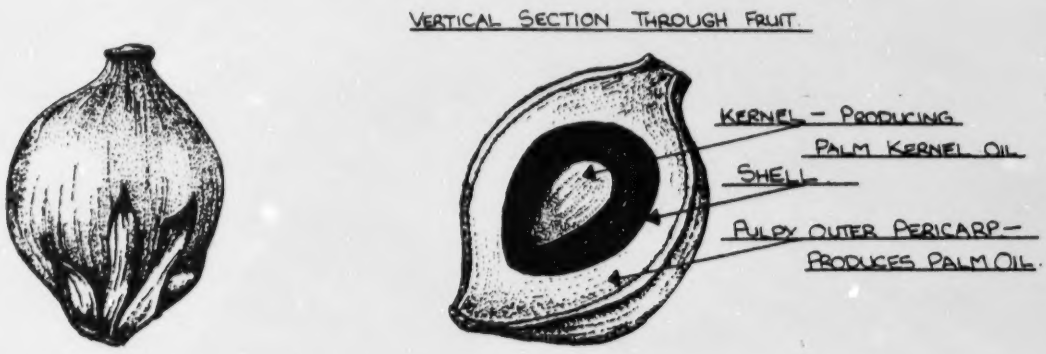
Soap Works in Tanzania



THE OIL-PALM

The Oil-palm (Elaeis guineenis) is a tall, graceful tree which will grow only in the hot, wet tropical regions with a rainfall of 60 inches or more. Oil-palm belts exist in West Africa, Malayasia and Indonesia. In West Africa, the tree grows wild in the vast rain-forests, especially in Southern Nigeria and Sierra Leone, and is a valuable source of vegetable oil for the manufacture of soap and edible fats.

Diagram of Individual Fruit

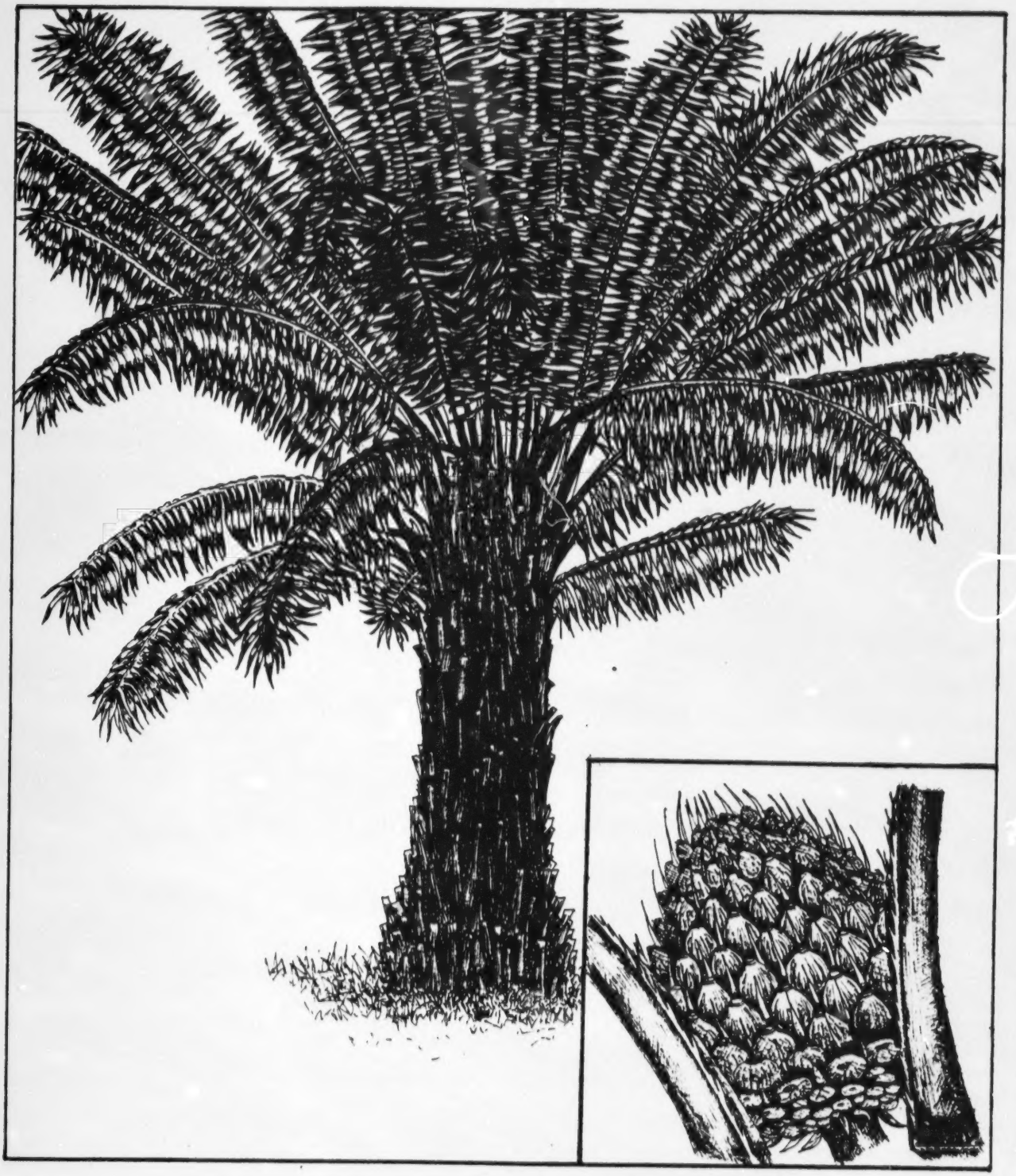


The fruits of the oil palm grow in large 'bunches' or 'heads' which form at the base of the fruits which grow out near the top of the trunk. A 'bunch' might consist of any number from a thousand to three thousand fruits closely and tightly attached to a tough, fibrous central mass. (See drawing) The 'bunch' weighs half a hundredweight or more. A plant might produce a dozen or more 'bunches' in a season.

The individual fruit, when separated from the bunch, consists of a pulpy outer pericarp, inside which is a nut with a hard shell enclosing a kernel. (See diagram) The pericarp is of a bright reddish-brown colour and the kernel has a dark oily appearance. PALM OIL is obtained from the pericarp, palm kernel-oil from the kernel. They are different oils and have different uses.

When the fruits are ripe for gathering, cutters climb the tree and cut off the bunches with matchets and let them fall to the ground. The bunches are picked up by the women and the work of extracting the oil begins. First the fruits are torn from the bunches. This is hard on the finger and to make the painful task easier, the bunches are left for a time under a covering of banana or plantain leaves. The fruits soften and can be more easily separated. Sometimes the softening is done by boiling the bunches in huge cauldrons.

The fruits are next pounded with wooden poles in large wooden mortars and



THE OIL PALM AND FRUIT.

Gambia ~

women separating palm kernel from fruit.

in this way the oil is squeezed from the pericarp. (See drawing and photograph) Sometimes the mashed-up fruits are placed in a wooden trough so that the oil runs down and is collected at the lower end in a can. The remaining pulp might be boiled again and more oil skimmed from the surface of the water.

POUNDING THE KERNELS.

Now there are small but more efficient oil-mills known as 'PIONEER MILLS'. In soap making the palm oil is bleached and boiled with an alkali e.g. soda or potash to become the soap 'base' to which other ingredients are added according to the type of soap required.

References

1. The preparation of soap - Dr. S.P. Bertram, Department of Development Co-operation - Eindhoven University of Technology
2. Modern Chemistry for Malaysian School - Ministry of Education, Malaysia - Longman
3. Soap and Detergents - A Social Treatment
   School Science Review Volume 60, Number 213, June 1979 pp 635-641
4. See pages 5 and 6 for further references

ACKNOWLEDGEMENTS

The Third World Science Project has been supported by a number of agencies and has drawn upon the expertise and goodwill of a vast number of individuals.

Pilot Project 1979-80 supported by the Overseas Development Fund

Writers: Trevor Roach, Philip Bladon Typing: Carole Johns
Graphics: George Robinson

Main Project 1981-82 supported by the Manpower Services Commission

Writers: Natalie Jones, Wyn Hughes Typing: Marjorie Eccles
Graphics: Karen Moss

In this phase of the project 100 sets of 14 Units have been produced and distributed to schools, teachers' centres and teacher training establishments. Draft material has been prepared for further Units.

Dissemination 1982-3 supported by the University of Wales

Faculty of Education Research and Publications Fund

Printing: University College of North Wales Print Unit

Distribution: The Centre for World Development Education, Buckingham Palace Road, London SW1W 9SH

The continued support and encouragement of Mr Dick Meakins of the CWDE is gratefully acknowledged

Sources The ideas and information incorporated in these Units come mainly from science teachers who are, or have been, teaching abroad. In some cases their pupils have also contributed. Some are known to us personally, others only through their letters, articles and books. We are very grateful to them all.

Wherever possible authors of published material and copyright holders have been approached for permission to reproduce extracts from their work. Where it has been impossible to trace the authors, apologies are offered.

For further information please contact

Professor Iolo Wyn Williams
Third World Science Project
School of Education
University College of North Wales
BANGOR, Gwynedd, U.K.

Copyright: Third World Science Project 1982